

Map Your Way to Strategic Investments in Process Safety

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Many CPI firms are looking at safety costs as investments, rather than expenses, and are reaping wide-range benefits. Here's a roadmap of how best to accomplish this.

The business and asset management challenges facing the chemical process industries (CPI) are characterized by a strong interdependence among businesses, global economies and markets, fast-paced technological innovation and competitive environments, and ongoing mergers and acquisitions. Other key factors include loss of experienced personnel, increased sensitivity of governments and communities to potentially undesirable events, increased regulation, and the mushrooming of communications and global sharing of information.

Managing the cost of technological risk

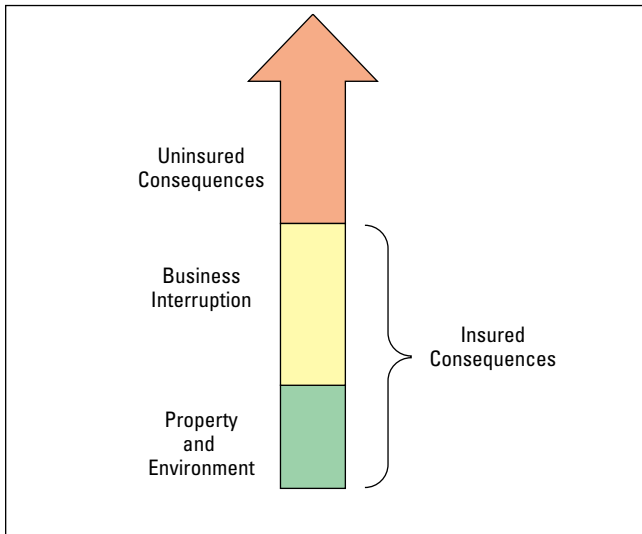
There is an opportunity for industry to continue improving the management of technological risk, while maintaining a competitive advantage and increasing profitability. Technological risk is comprised of several loss components (Table 1). The consequences often have insured and uninsured portions. The uninsured portions relate to potential events that a firm can experience with no risk-transfer mechanisms in place, either intentionally or unintentionally (Figure 1).

In other words, these losses have outcomes that will directly affect a company's success and profitability, since there are no safeguards. Such events are often associated with intan-

gible assets (*e.g.*, corporate image, market share, investor confidence, employee relations, and retention), as well as property and perils excluded from the insurance policy.

Managing the costs of the insured elements is difficult enough, but most safety professionals are able to do so. However, some of the uninsured consequences are often ignored, for example, self-insured retention (related to property, business interruption, environment and personnel), fees/taxes/charges, market share, costs of regulatory compliance, and the corporate image. Given limited funds, how can one allocate the safety dollar wisely, and not neglect such items? Here, we will present a method to make wise investments in safety. We will view safety as an investment, rather than an expense, and show how this makes good business and engineering sense.

| Table 1. Loss components can have wide-ranging consequences. | |
|--|---|
| Loss Components | Associated Consequences |
| Operational | Loss of productivity, product quality, and new product development |
| Safety | Property damage, potential harm to people and the environment |
| Financial | Reduced return on investment, cash flow, and business interruption |
| Legal | Product liability, litigation arising from sensitivity of governments and communities to potentially harmful events and operating permits |
| Political | Regulatory recourse, civil disturbance |



■ Figure 1. Hierarchical consequences of a loss.

| | | | | |
|--|---|--|--|--------------------|
| Few Companies (Leaders) Some Companies Majority of Companies | Strategic Business Goals | "Strategic" Investment in Process Safety | Protect Against Uninsurable Losses | Desired State ↑ |
| | Multinational Regulations and Standards | Integrated PSM Performance-Based | Reduced Compliance Costs, Flexibility | |
| | Local Regulations and Standards | "Nonintegrated Compliance" | Avoid Liability, Penalties, Operational Objectives | |
| | Industry Drivers | Technical Approach | Business Benefits | |

■ Figure 2. Relationship between investment drivers, approach, and benefits.

Industry drivers supporting process safety

Undesired consequences associated with tangible and intangible assets do take place, and, often, with major business impacts. So, how can a company justify the necessary expenses to protect against these consequences in a highly competitive environment?

As already mentioned, one way is to see the benefit received from process safety as an investment, rather than the incurred cost as an expense. In other words, can the transfer of process safety from the expense to the investment side of the business ledger be justified, and, if so, how? This justification should answer:

- Why should a firm strategically invest in process safety?
- What are the drivers that will support this investment?
- What are the potential total benefits?

Figure 2 shows the relationship among these drivers, related technical approaches, and business benefits. The majority of companies comply with local regulations and standards because they want to meet operational objectives and avoid penalties and liabilities. They meet the minimum requirements with minimal investment. Their focus is opportunistically to satisfy short-term operational objectives.

Some firms, particularly multinationals, comply with international standards and regulations in addition to the elements in the bottom row in Figure 2. These standards and regulations rely on performance-based metrics and are amenable to an integrated compliance approach, especially in the CPI. The benefits, in addition to those in Figure 2, are reduced compliance costs, because of the international character of the standards, uniformity of implementation at all plants, and flexibility of evaluating and implementing alternative practical and cost-effective safety solutions that meet the performance-metrics.

A few businesses, the industry leaders, follow all of these approaches. Also, they make process safety decisions driven by their strategic goals and objectives. These companies integrate their investment in process safety with their asset management strategy to realize all the benefits mentioned so far, and, more importantly, to protect against the financial impacts of losses with uninsured consequences.

Strategic investment in process safety

Becoming an industry leader and safeguarding against losses, particularly the uninsured portion, requires a long-term corporate commitment and a strategic investment in process safety (Table 2). For such an investment, the benefits include: (a) more opportu-

Table 2. Elements of a strategic investment in process safety.

Plan Elements

1. Compliance with international performance-based standards and regulations.
2. An integrated process safety management program.
3. Risk-based loss analysis or risk assessment.
4. Cost/benefit analysis relating the investment in process safety to company financial metrics.
5. Corporate safety culture that supports strategic investment in process safety.

Safety

Table 3. Some performance-based standards and regulations.

| Year | Industry Regulations and Standards |
|------|---|
| 1982 | SEVESO Directive — European Community |
| 1984 | CIMAH (Control of Industrial Major Hazard Regulations) — U.K. |
| 1990 | API RP 750 — American Petroleum Institute's Management of Process Hazards — U.S. |
| 1992 | "Process Safety Management of Highly Hazardous Chemicals," OSHA 29 CFR 1910.119 — U.S. |
| 1995 | "Risk Management Programs for Chemical Accidental Release Prevention," EPA 40 CFR Part 68 — U.S. |
| 1996 | "Application of Safety Instrumented Systems for the Process Industries," ANSI/ISA S84.01 — U.S. |
| 1998 | SEVESO II Directive — European Community |
| 1999 | "Functional Safety of Electric, Electronic and Programmable Electronic Safety-Related Systems," IEC 61508 — International |
| 2001 | "Functional Safety: Safety Instrumented Systems for the Process Industry Sector," IEC draft 61511 — International |

nities to achieve business objectives such as improved process availability, fewer unwanted incidents, and increased market share; (b) greater chances to motivate, educate, and

retain employees; (c) greater likelihood to manage the public image and be viewed as a good neighbor, noble employer, a reliable supplier, and a strong competitor; and (d) more opportunities to gain a competitive advantage and lead the industry.

Performance-based standards/regulations

Standards provide the foundation for all aspects of systems and processes. They often offer general direction and guidance based on the consensus work of experts, but do not necessarily offer distinct solutions for a specific process or safety concern. Input from professional associations, industry sponsored groups, government agencies, international associations, and companies are used to develop two types of safety standards: prescriptive and

performance-based.

Prescriptive standards are traditionally developed based on acceptable engineering principles and practices. They

Table 4. Elements of integrated process safety management.

| Risk Program Elements | OSHA PSM | EPA RMP* | ANSI/ISA S84.01 | IEC 61508 | Seveso Directive* | Integrated Process Safety Management |
|--|----------|----------|-----------------|-----------|-------------------|--------------------------------------|
| Process Safety Information | ● | ● | ○ | ○ | ● | ● |
| Operating Procedures | ● | ● | ● | ● | ● | ● |
| Training | ● | ● | ● | ● | ● | ● |
| Mechanical Integrity | ● | ● | ● | ● | ● | ● |
| Incident Investigation | ● | ● | ● | ● | ● | ● |
| Compliance Audit | ● | ● | ●† | ● | ● | ● |
| Management of Change | ● | ● | ● | ● | ● | ● |
| Pre-startup Review | ● | ● | ● | ● | ● | ● |
| Contractor Program | ● | ● | | | ● | ● |
| Employee Participation | ● | ● | | | ● | ● |
| Trade Secrets | ● | | | | | ● |
| Hot Work Permits | ● | ● | | | ● | ● |
| Emergency Response Program | ● | ● | | | ● | ● |
| Process Hazards Analysis | ● | ● | ● | ● | ● | ● |
| Consequence Analysis | | ● | ● | ● | ● | ● |
| Accident History | ● | ● | | | ● | ● |
| Risk Assessment | ●‡ | ●‡ | ● | ● | ● | ● |
| Risk Management | ● | ● | ● | ● | ● | ● |
| Management Program § | | ● | ○ | ● | ● | ● |
| Life-Cycle Safety (design, installation, operation, maintenance, decommissioning) ○# | ○# | ○# | ● | ● | ○ | ● |

● = Element needs full compliance under this rule or standard.

○ = Element needs implied or partial compliance.

* Different tiers of requirements exist for processes with different risks.

† ISA requires a SIS design to be "verified" and therefore constitutes an audit process over the life cycle of the SIS.

‡ Risk assessment is accomplished through the "Process Hazards Analysis" noted above.

§ Management program is a management system to oversee the implementation of risk management plan.

Life-cycle evaluation for OSHA PSM and EPA RMP is implemented in part in audits, as well as revalidation requirements for PHAs during the operation of a covered process.

Table 5. Risk-based loss analysis.

| Uninsured Loss | | | | Strategic Investment in Safety | | | |
|--|-----------------|-----------|---|--|---------------------------|---------------------------|--------------------------|
| Consequence of Loss | Loss Likelihood | Loss Cost | Risk or Expected Cost/Yr | Process Safety | Loss Likelihood | Loss Cost | Risk or Expected Cost/Yr |
| Property, environment and loss of market share | L_1 | $C_1 =$ | $E_1 = L_1 \cdot C_1$ $C_A + C_{MS}$ | Additional protection and prevention systems | L_2 where $L_2 \ll L_1$ | $C_2 =$ $C_A + C_{MS}$ | $E_2 = L_2 \cdot C_2$ |

Table 6. Cost/benefit analysis.

| Year | Cost | Benefit |
|--------|-------------------|---------------------|
| 1 | $C_S + C_{OC}/5$ | $E_1 - E_2 = B_1$ |
| 2 | $C_{OC}/5$ | B_2 |
| 3 | $C_{OC}/5$ | B_3 |
| 4 | $C_{OC}/5$ | B_4 |
| 5 | $C_{OC}/5$ | B_5 |
| 5 Year | Total Present | Total Present Value |
| Total | Value Cost, PVC | Benefit, PVB |

are founded on the history of undesired events and time-tested safety solutions. They constitute the current level of our knowledge and concentrate on prescribing specific safety solutions to predefined deviations from normal operations. Therefore, they are general solutions to a set of abnormal conditions that are limited by past experience. Precisely for these reasons, they often do not provide the optimal solution to specific safety concerns. Rather, they present a prescription to a general set of known safety concerns and attempt to deal with other unknown problems by using conservative safety factors.

Recognizing their limitations, the CPI have been focusing on developing performance-based standards. Similarly, government agencies have published such regulations. The goals of this approach are to improve the management of technological risk by setting process-specific, performance-based targets, such as process safety target levels, and by consistently evaluating alternative solutions to achieve these targets.

This method is characterized by: (a) the detailed examination of a specific process; (b) the specification of safety solutions that account for the intricacies of the process; and (c) the identification of optimal process safety solutions. The success of this approach does not depend upon compliance to the minimum requirements of a prescriptive standard. It does require corporate commitment to process safety and a cultural change that relies on a continuous and long-term commitment to understanding, evaluating, and improving the safety of an industrial process.

Performance-based standards rely on risk metrics to support prudent business decisions and are borne by a safety culture nurtured and directed by top management. An abridged list of some such major standards and regulations is given in Table 3.

Industry will continue to develop performance-based standards that follow life-cycle models, which include the process itself, all safety/control equipment, and people (operators and community). Eventually, the CPI may find a

worldwide promulgation of different performance-based regulations and standards. This may create a problem similar to that with prescriptive standards — without clear policies and procedures that are accepted by key stakeholders, this may, in fact, increase manufacturing costs and create confusion in industry and regulators.

One solution is relying on international standards and regulations. In a highly competitive global market with varying economic forces at work, it makes good business sense to have consistent requirements and comply with international standards such as ANSI/ISA S84.01 (1), IEC 61508, (2) or, in the future, IEC 61511 (3) for the process industries.

Integrated process safety management

Traditional compliance to international performance-based standards and regulations is not enough. Compliance should also be practical and cost-effective. That is, it should combine common safety elements from different standards and regulations into one program to allow a task to be done once, yet claim conformity to the same or similar requirements in a set of performance-based standards and regulations. This approach is highlighted in the integrated process safety management program (4) (Table 4). The program avoids redundancy and overlap, while complying with the safety elements of all five national and international standards and regulations.

Risk-based loss analysis

It is not always possible to eliminate every risk in a plant to affect compliance. Only tolerable risks, as defined by standards and good engineering practice, are acceptable. To do so, assess the risk associated with a particular loss and see if the risk is tolerable. If it is not, then process safety improvements are needed to reduce it to or below the tolerable level.

A simple example is shown in Table 5, which is based upon well established techniques used by industry for years. These have recently been mandated in national and international standards and regulations (1, 2, 5, 6).

In this example, assume that a loss may occur that has an impact on the environment and property, and will force a shutdown of a critical, one-of-a kind-process, with significant business interruption. Traditional risk assessment will develop the accident (loss) scenario using one of several assessment techniques, and will include the cost associated with the consequences. However, there may also be uninsured outcomes, such as loss of market share, that traditionally are not included in the analysis.

Safety

The first four columns of Table 5 present the data associated with the risk of a loss that also has uninsured consequences. Column 1 identifies typical uninsured consequences that the loss may have. Column 2 shows the likelihood of occurrence of the specific accident with insured and uninsured consequences L_1 , while the third column lists the total cost of the event C_1 . This includes the cost elements traditionally included in risk assessment, such as those associated with the environment, property, and business interruption C_A .

The additional cost is that of loss of market share C_{MS} . This may include costs such as those of: lost sales; new marketing initiatives to recapture market share; re-establishing relationships with key suppliers and customers; etc. Column 4 is the “expected cost” E_1 , the risk associated with the loss, often expressed as dollars lost per year. The right four columns relate to the process safety improvements needed to reduce E_1 . Here, the focus is on prevention (*i.e.*, reducing the likelihood of occurrence). However, mitigation can also be used.

Column 5 identifies process safety improvement recommendations that can be implemented to reduce the likelihood of occurrence. These may include additional protection, mitigation and prevention systems, new operational/emergency procedures and related training, and changes in the production process including material handling and storage, among others. Column 6 is the likelihood L_2 that the specific loss leads to the consequence in the first column, which may occur after the process safety improvements identified in Column 5 have been implemented. In this example, prevention techniques are used and, therefore, L_2 should be much less than L_1 . The degree to which this is so depends upon the number of new safety improvements and their performance (*i.e.*, reliability, availability).

Column 7 is the total cost of occurrence for the same loss C_2 . This cost is the same as that in Column 3 (C_1), because the example considers only prevention and not mitigation. However, if measures were taken to also reduce the consequences, then C_2 would be less than C_1 . Finally, Column 8 is the new expected cost E_2 , which equals $L_2 \times C_2$. Note that C_2 may include the cost of implementing the improvements. In this example, this cost is examined in the following cost/benefit analysis.

Table 5 shows that the same loss may take place with the same insured and uninsured consequence (*e.g.*, loss of market share), even after implementing the safety improvements. However, adding new safety or protection systems reduces the likelihood of occurrence and, therefore, the associated risk. If E_2 is significantly less than E_1 , then an analysis is needed to compare the cost of implementing the improvements with the benefits of potential risk reduction.

Cost/benefit analysis

The analysis (Table 6) compares the costs of process safety benefits with benefits such as increased sales, retention or in-

crease in market share, lower litigation and public relations costs.

In this example it has been assumed that:

- The basis is 5 yr. Other times are often used in industry.
- The total cost associated with safety improvements C_S has been expended in the first year. Further, the funds were available and, thus, do not depend on a spending pattern or financing.
- If the funds for process safety improvements were instead invested for 5 yr, then the total (5-yr) return on this investment would be defined as the opportunity cost C_{OC} . The total return on this investment is assumed known and is linear over the 5 yr.
- The incremental benefit B_1 , the reduction in risk from Table 5, is equal to $E_1 - E_2$, and is linear over 5 yr. While $B_1 \dots B_5$ appear as benefits, they are actually an unrealized annualized incremental reduction in the expected cost of the loss.

The total cost PVC (summation of Column 2) and total benefit PVB in Column 3, respectively, should be transferred into present value dollars (*i.e.*, for the current year) using established accounting practices. The decision to strategically invest in process safety and safeguard against the loss of market share is justified if:

1. E_2 (from Table 5) is below the firm’s tolerable level.
2. PVB is significantly greater than the cost, PVC . The level of significance often depends on corporate policy and business conditions.

The cost-benefit analysis in Table 6 is one of many techniques available. Other comparison methods can be used, as long as they treat both parameters consistently (7, 8).

Corporate safety culture

The three key elements of this critical culture are (9) consensus and practice from top management (good leader), and consensus and participation by employees (good employer), and stakeholders (good neighbor).

The first is perhaps the most critical for a successful investment in process safety. It requires a long-term philosophy and a financial commitment by senior management, plus an affirmation that safety is one of the strategic objectives of the company.

Consensus and participation of employees support the operational and strategic objectives of a company, as well as foster a safe working environment that helps improve safety, productivity, and product quality. Employee participation has been initiated by some industry leaders in the CPI, and adopted by the U.S. Occupational Safety and Health Administration’s Process Safety Management program (26 CFR 1919.119) and the Environmental Protection Agency’s Risk Management Program (40 CFR Part 68). Similarly, many leading companies have, for years, been practicing the good neighbor policy.

A company can demonstrate a corporate commitment to safety by partnering with all stakeholders to develop a safety policy that addresses all concerns. Such stakeholders include

employees, the community, concerned public-interest groups, and members of the insurance industry that have demonstrated the same level of commitment to loss prevention.

The Center for Chemical Process Safety is taking an active role in promoting safety as a business issue (see sidebar).

To sum up

Strategic investment in process safety to protect against losses with insured and uninsured consequences can be

CCPS Sees Safety as a Business Case

To support the need for sound corporate management systems in process safety, the Center for Chemical Process Safety (CCPS) undertook a project to develop a rational "Business Case" for process safety. Data gathered from CPI companies as part of this project indicate that a successful process safety program can provide four major benefits to corporations: (1) freedom to manage the business (self-termination); (2) avoidance of major losses of life and property; (3) corporate image as a good member of the community; and (4) positive business value derived from improved management systems and manufacturing processes. The results will be discussed at CCPS's Annual Conference in Toronto on October 2–6, prior to publishing. CCPS can be reached at (212) 591-7319 or at ccps@aiiche.org.

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achieved by taking advantage of all of the engineering and business services available, such as risk identification, and quantification and risk management. Through these, a company will have a better understanding of its risk, which, in turn, will lead to improved recommendations for practical and cost-effective risk management solutions that reduce the costs of accidents.

There are many firms that have identified the need to safeguard against uninsured consequences and are leading industry by strategically investing in process safety. They have achieved this status by: following the five basic elements to strategically invest in process safety (Table 2); allocating particular effort and resources to the development of a corporate safety culture and the business case (cost/benefit analysis); and by their willingness to partner with stakeholders that have a long-term and proven commitment to safety. The proliferation of international performance-based standards and the competitive advantage that industry leaders gain from strategically investing in process safety will drive others to follow in their footsteps. These companies will understand that it makes better business sense to follow this path.

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